Photon + jet measurements at the Tevatron

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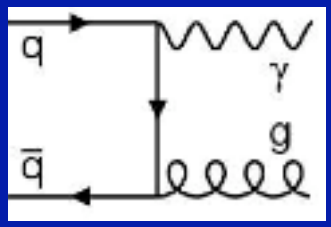
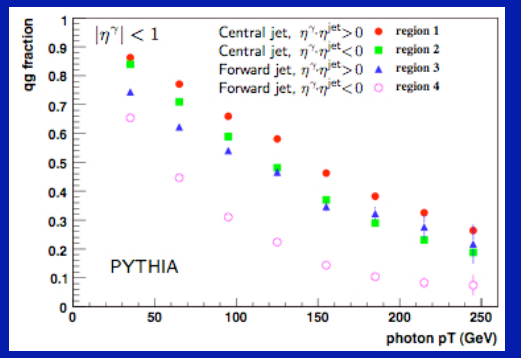
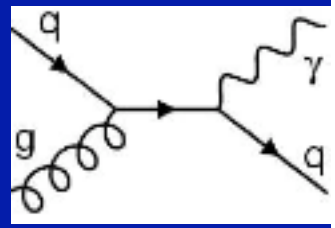
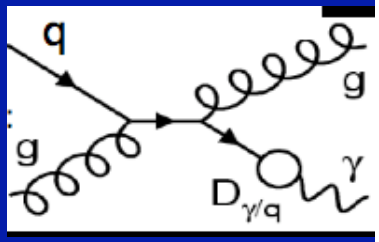
Some theory background



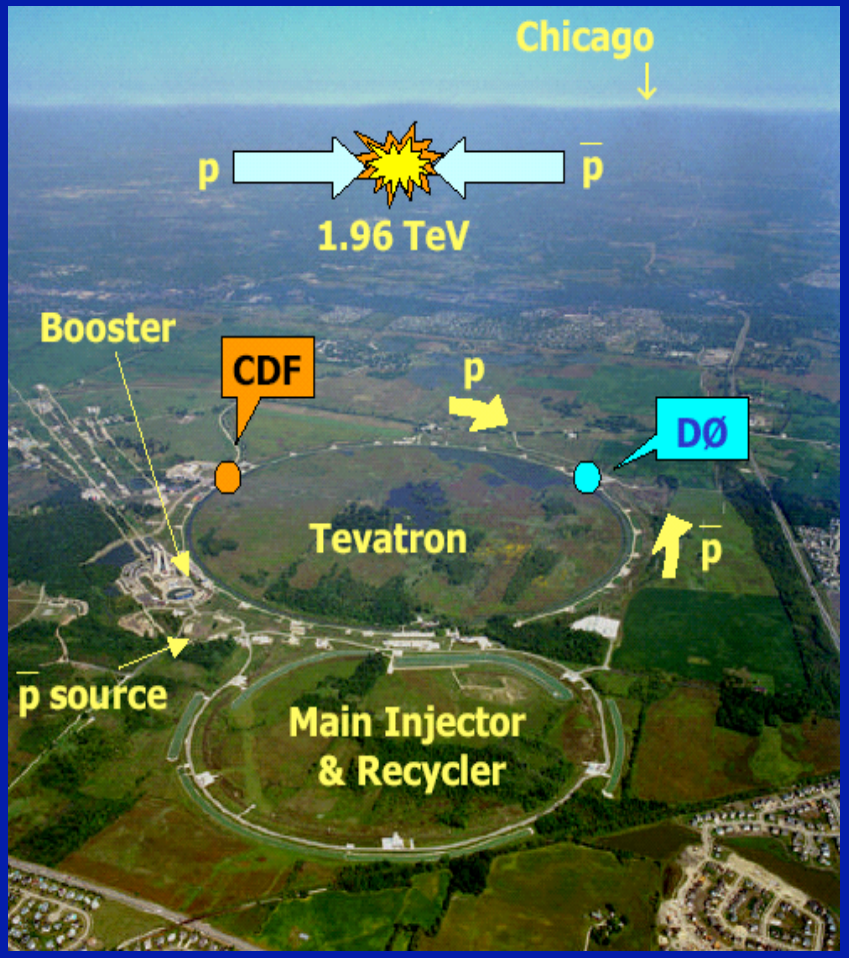
- At first order: direct photons
  - direct probe of hard scattering dynamics
- At pT < 120 GeV dominated by qg process
  - Fragmentation becomes relevant
- Relevant to constrain PDF's:
  - Light-quark final states: sensitive to gluon density (since quark PDF's constrained by HERA data)
  - Heavy quark final states, sensitive to HF Pdf's
- In general, sensitive to soft gluon resummation, perturbative NLO QCD
- Photon final states predicted in most popular new physics models (SUSY, ExtraDimensions, TechniColor, Compositeness, 4th generation)







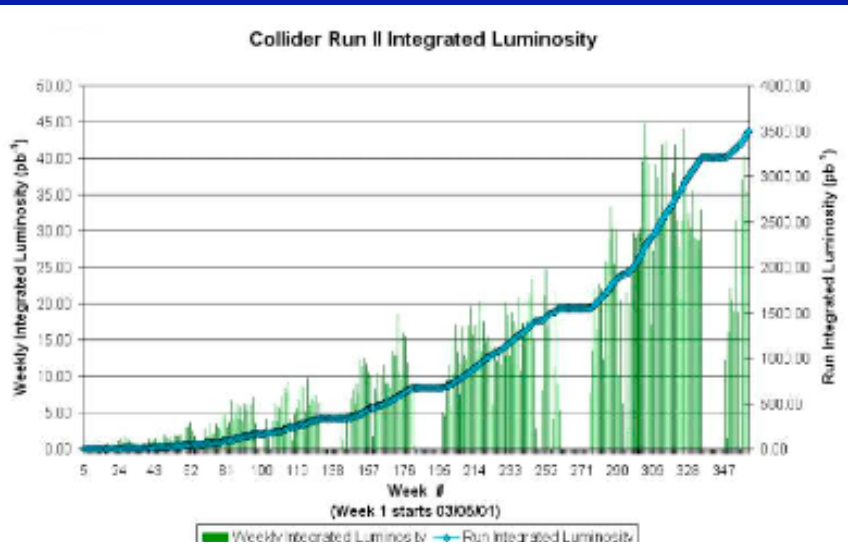
Some Tevatron numbers



- World's largest hadron collider
- First large-scale super-conducting magnet (4.2 T) accelerator
- 6.28 Km length, theoretical maximum about 1.4 TeV per beam
- $\sqrt{s}$ = 1.96 TeV
- Started operation in 1987 (run 0), then collected about 100 pb^{-1} until 1996 (run I), then a long shutdown until 2000, and Run II between 2001 and 2009

3.8 fb^{-1} delivered (6-8 expected in 2009)

Peak luminosity: 3.12 10^{32} cm^{-1} s^{-1}



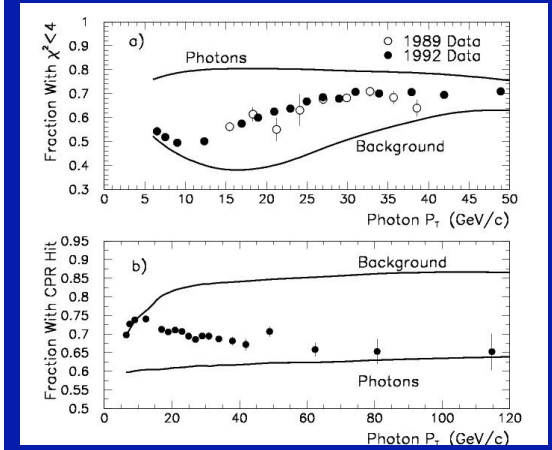
Photon identification in Tevatron detectors

CDF Calorimeter:

- CEM lead + scint $13.4\%/\sqrt{E_t}\oplus 2\%$

Photon identification detectors:

- Shower shape measured by two wire chambers, compared to simulation



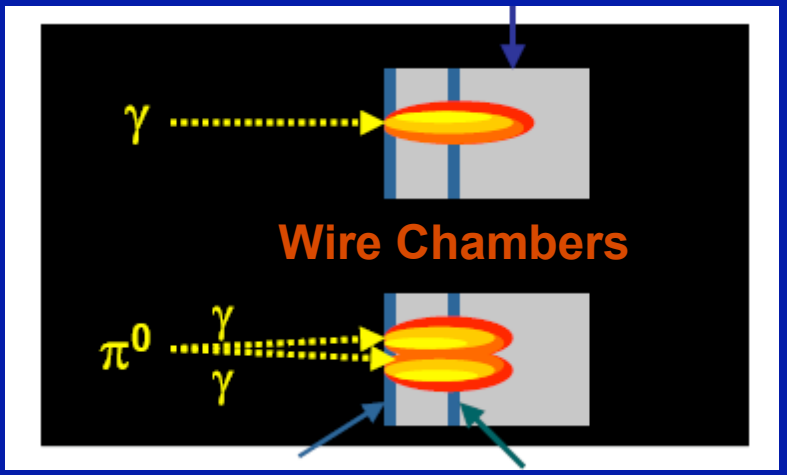
D0 Lar calorimeter:

Fine segmentation 0.1 x 0.1

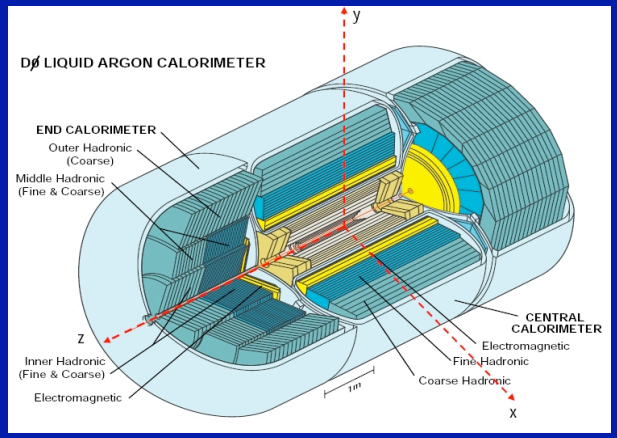
0.05 x 0.05 at shower max

Resolution about $15\%/\sqrt{E}$

Central Electromagnetic Calorimeter



Pre-shower (CPR) Shower Maximum (CES)



Triggering and selection for photons

Photon + X triggers

Et > 25 GeV with iso (50 w/o iso)

2 x (Et > 12) with iso (18 w/o iso)

γ+μ, γ+b,γ+2 jet, γγγ

Central (η<1.0) and forward (1.2<η<2.8) cuts

Had/EM<0.055 (0.05)

Energy in 0.4 cone < 2 GeV

Leading track Pt < 1 GeV

Pt tracks in cone 0.4 < 2 GeV

Shower shape cuts

Efficiencies checked with Z->ee, minbias

Photon triggers:

Et > 25 GeV, iso<0.2, had/em<0.2 (presc.)

Et > 30 GeV, iso<0.2, had/em<0.2

Analysis cuts (η<1.1):

Had/EM<0.04

Energy fraction
(0.2<ΔR<0.4)/(ΔR<0.2) <0.07

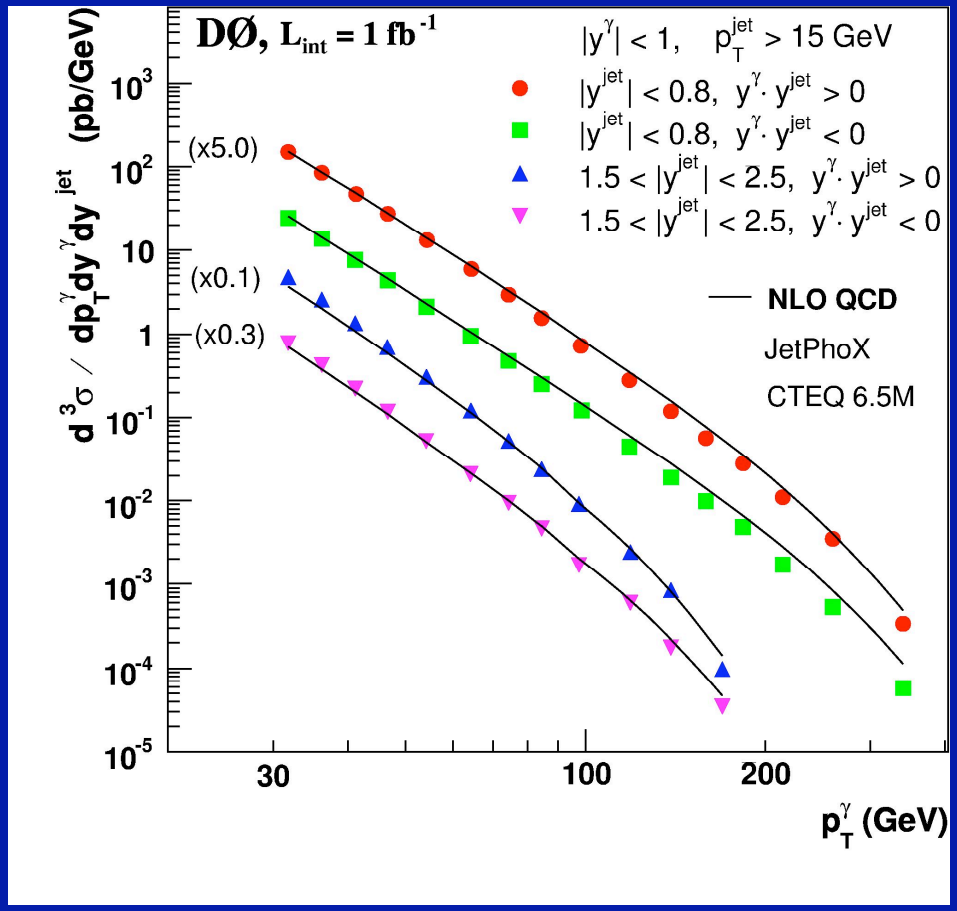
High-pT track veto

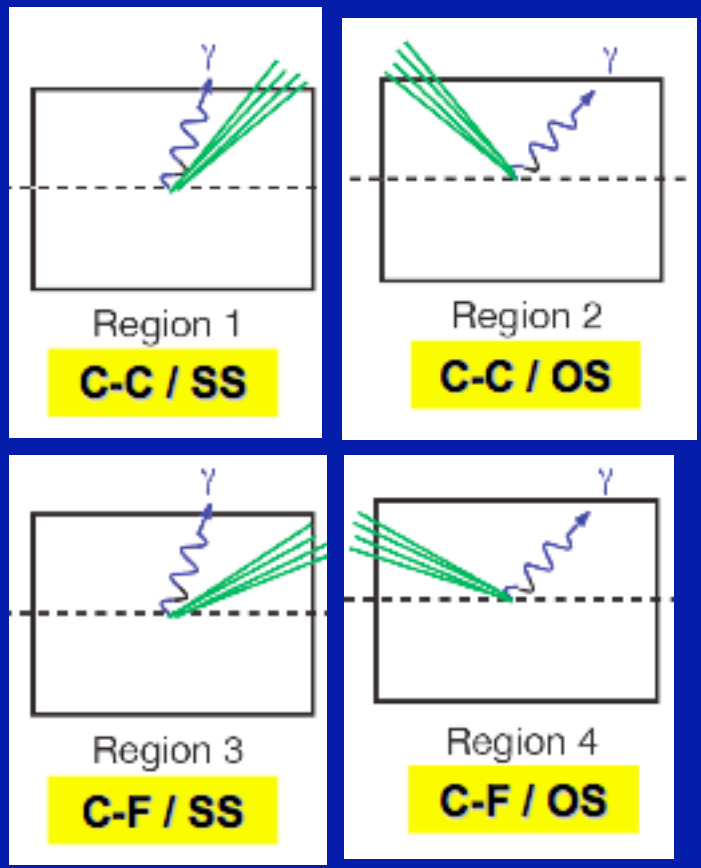
Track pt in (0.05<ΔR<0.4)< 2 GeV

Efficiencies checked with Z->ee

D0 photon + jet

"Triple" differential cross section (in two bins of jet and photon rapidity)





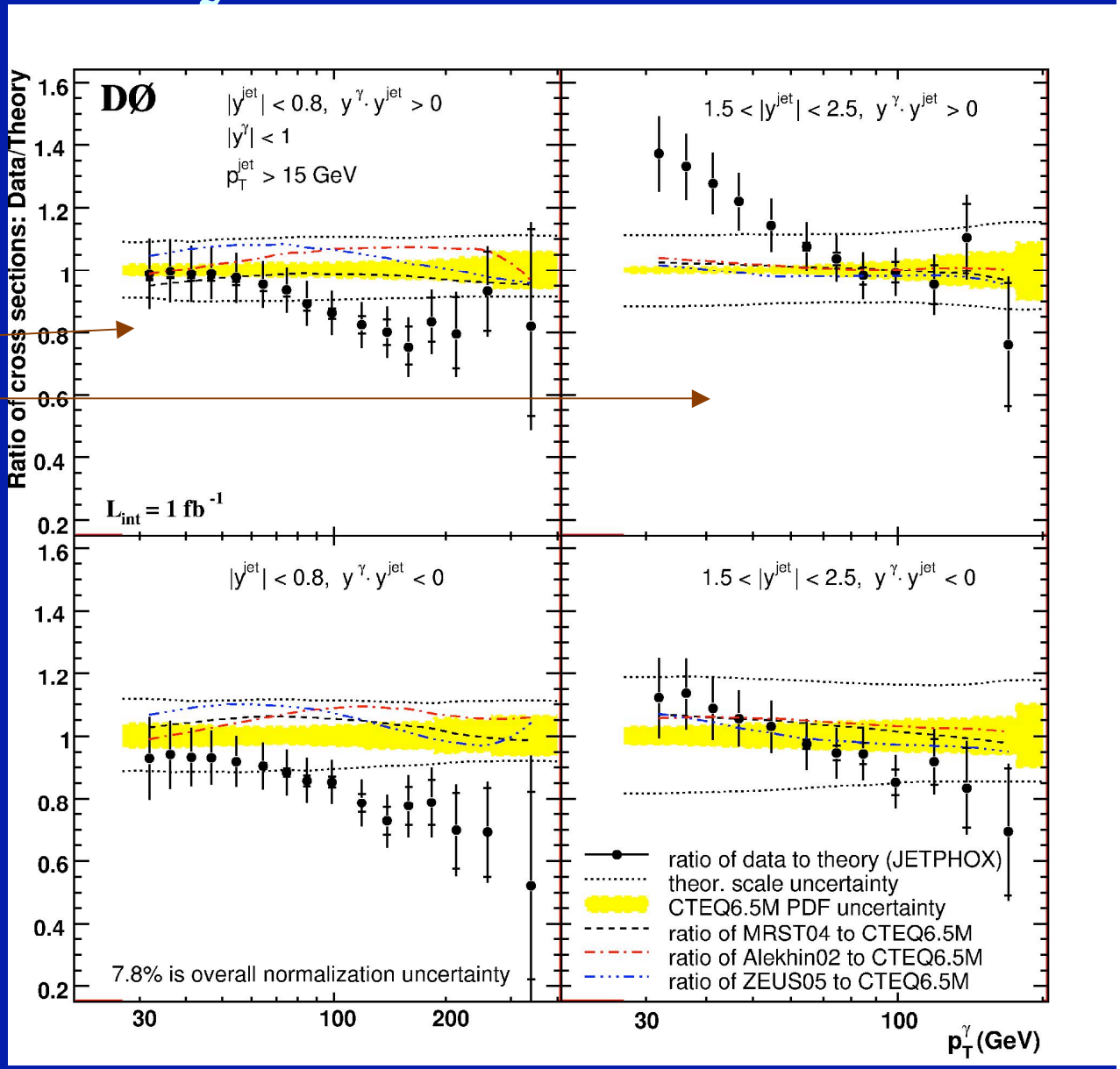
Experimental points unfolded to parton level

Theory curve is JETPHOX (NLO) CTEQ 6.1M

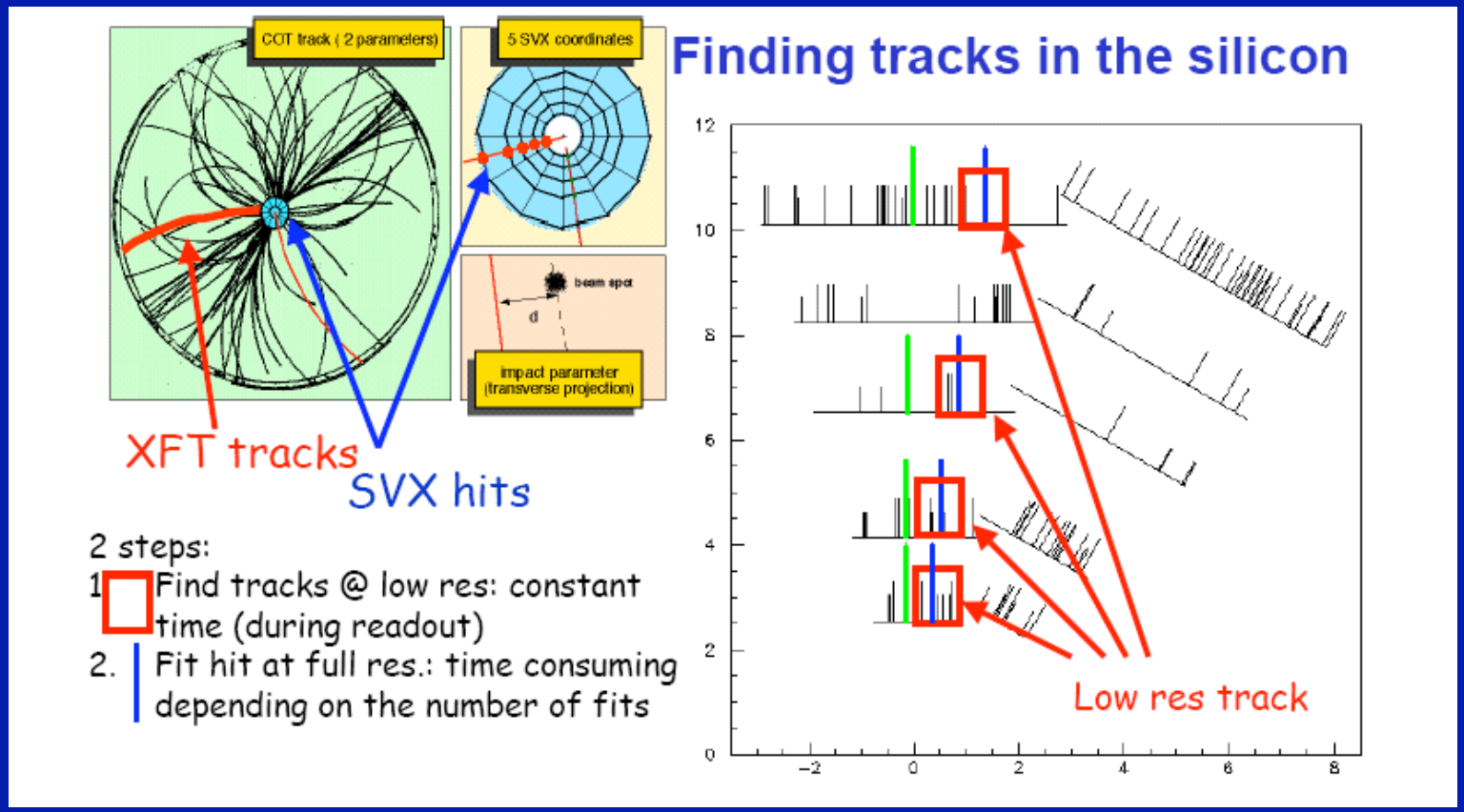
Ratio with theory

Discrepancies observed for same-side jets, both forward and central. Already seen in inclusive photons by UA2, CDF, D0

Investigations under way, likely to be problem with interplay between fragmentation and soft terms



CDF photon + b measurement with a dedicated trigger (SVT)

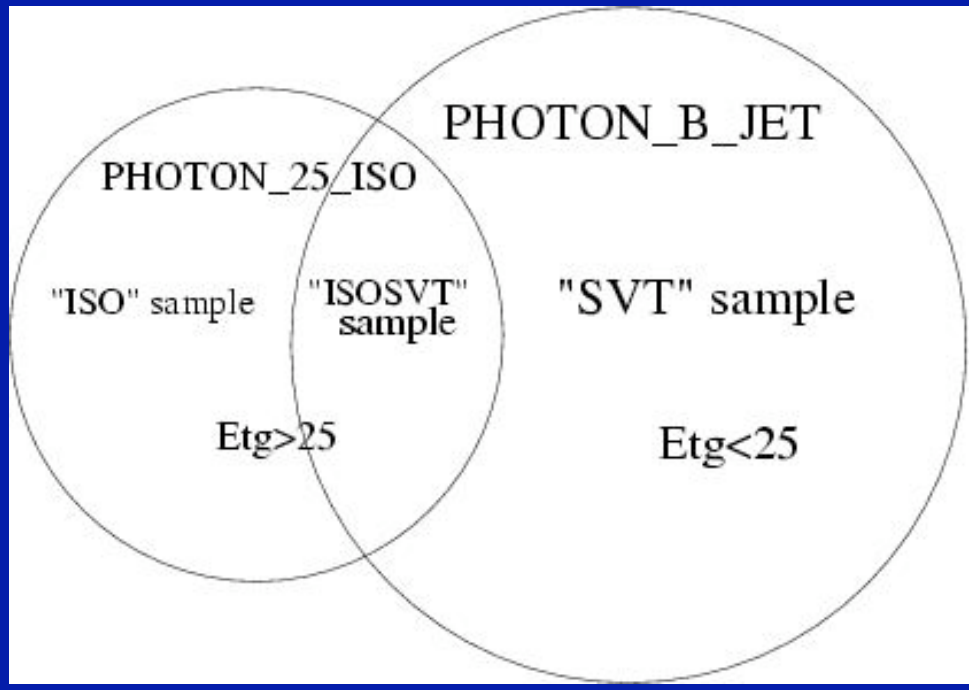


1. Find low resolution track (road) in COT
2. Discretize ϕ, Pt of road and SVX hits
3. Compare with pre-calculated configurations (in associative memory): no fit performed!
4. Track parameters found in few μs

B-enhanced vs unbiased dataset

Two analyses performed on very different datasets:

- Unbiased with pT(γ)>25
- SVT-based with pT(γ)>12 GeV without prescale!



$$\sigma_{ISO} = N_{ISO} f^{b}_{ISO} / \epsilon^{tag}_{ISO} / \mathcal{L}$$

$$\sigma_{SVT} = N_{SVT} f^{b}_{SVT} / \epsilon^{tag}_{SVT} / \epsilon^{trig}_{SVT} / \mathcal{L}$$

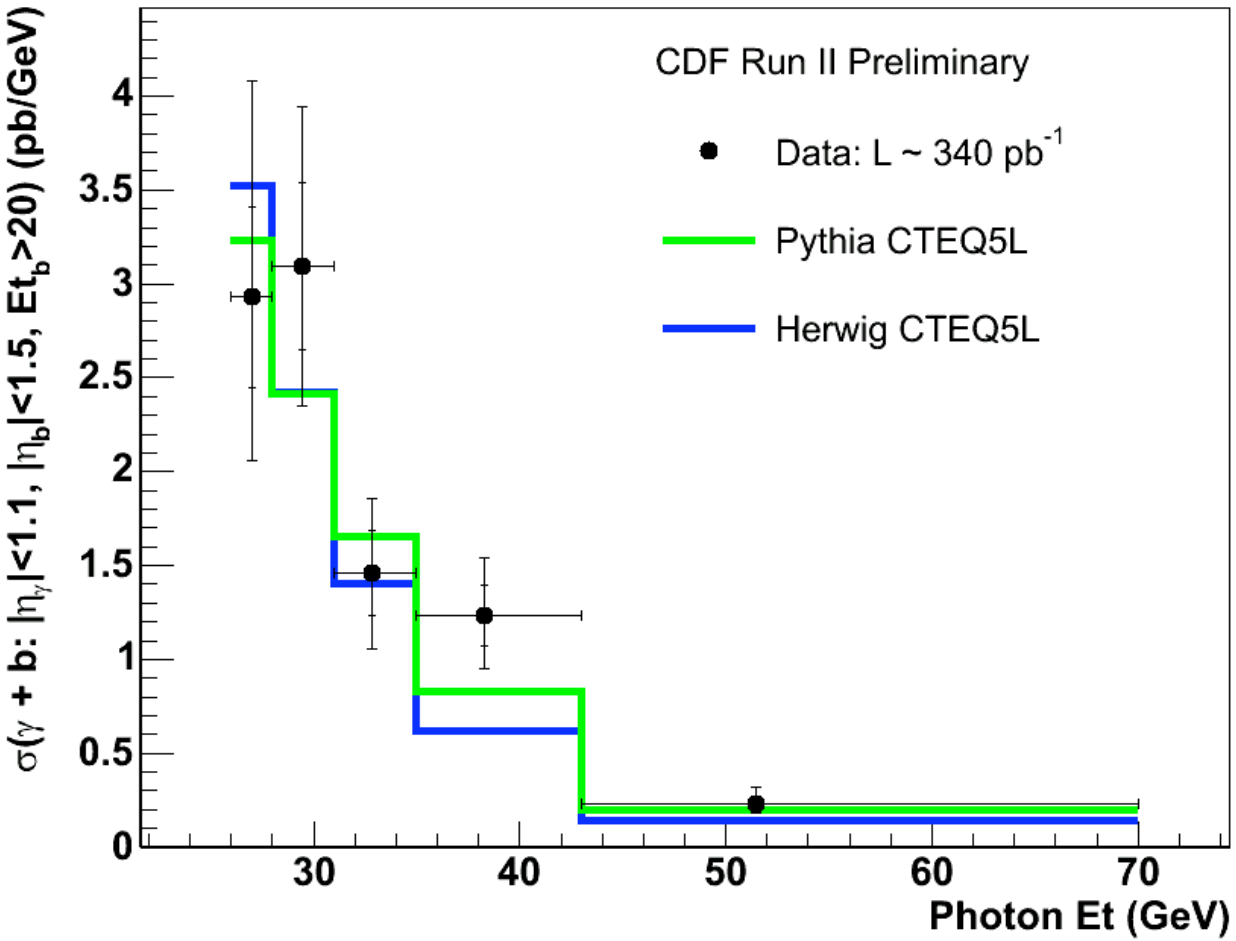
Requires trigger simulation

Hard to calculate

Trigger efficiency can be computed directly from data using the overlap region, where events have photon Et above 25 GeV and an SVT track, and extrapolated to low photon pT region

Only assumption: trig efficiency independent on photon energy

Photon + b result on unbiased dataset

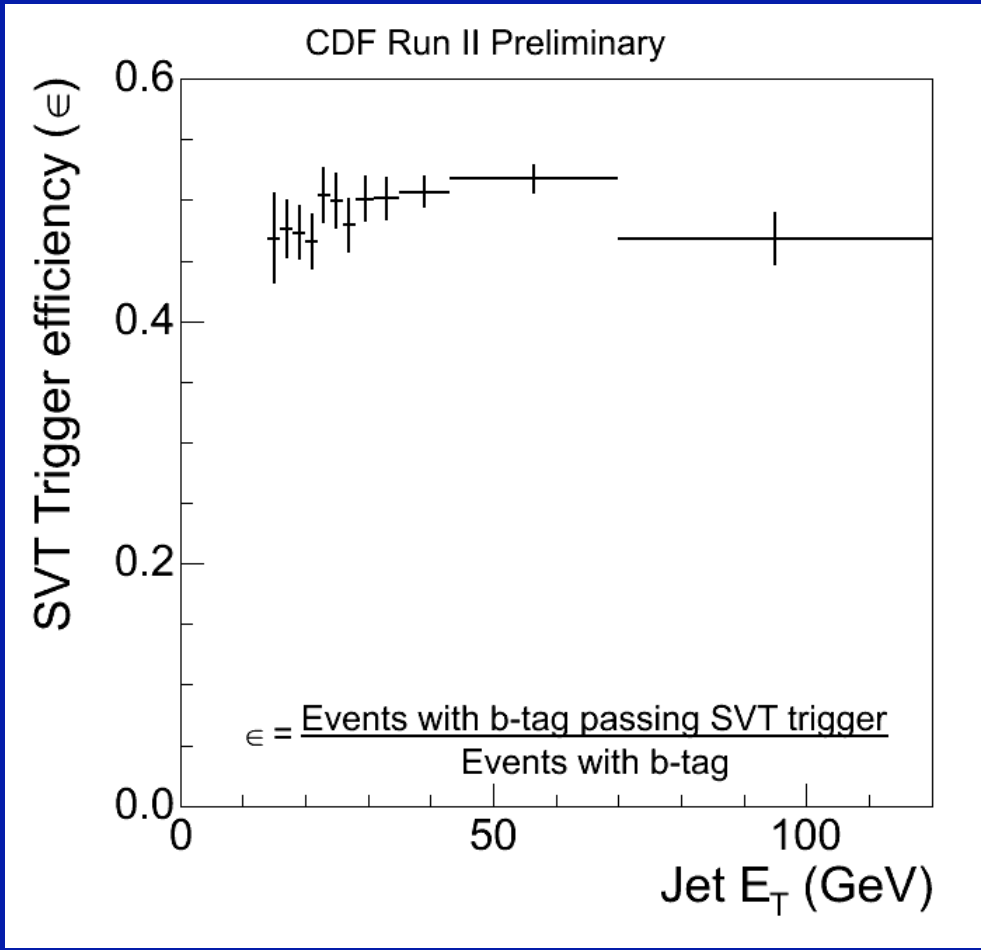


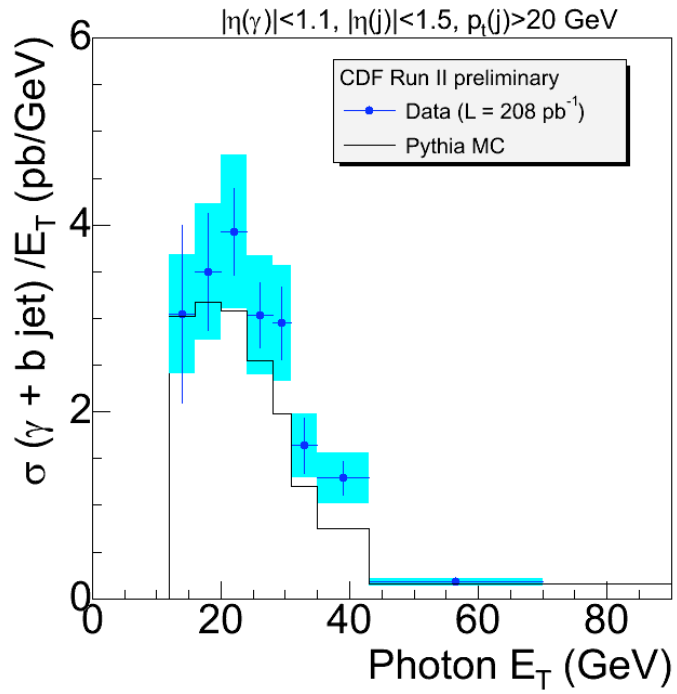
Cross sections and ratio agree with LO predictions from MC, but on the high side

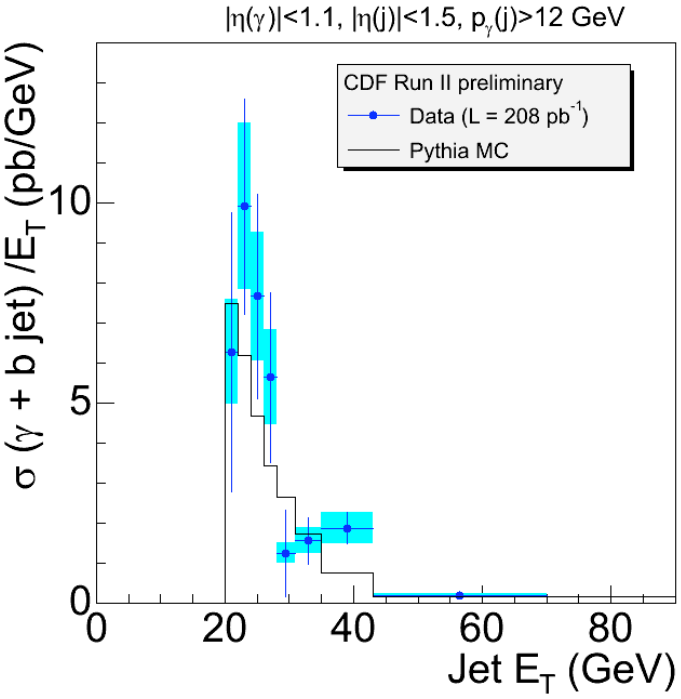
Trigger efficiency: Et dependence

Trigger efficiency was found to be stable with run number, for the different trigger conditions.

Trigger efficiency is also constant as a function of jet Et (small dependence used in the analysis)







Photon+b cross section on the SVT dataset

Very good agreement with previous measurement based on PHOTON_25_ISO (~45% candidate overlap)

Data:

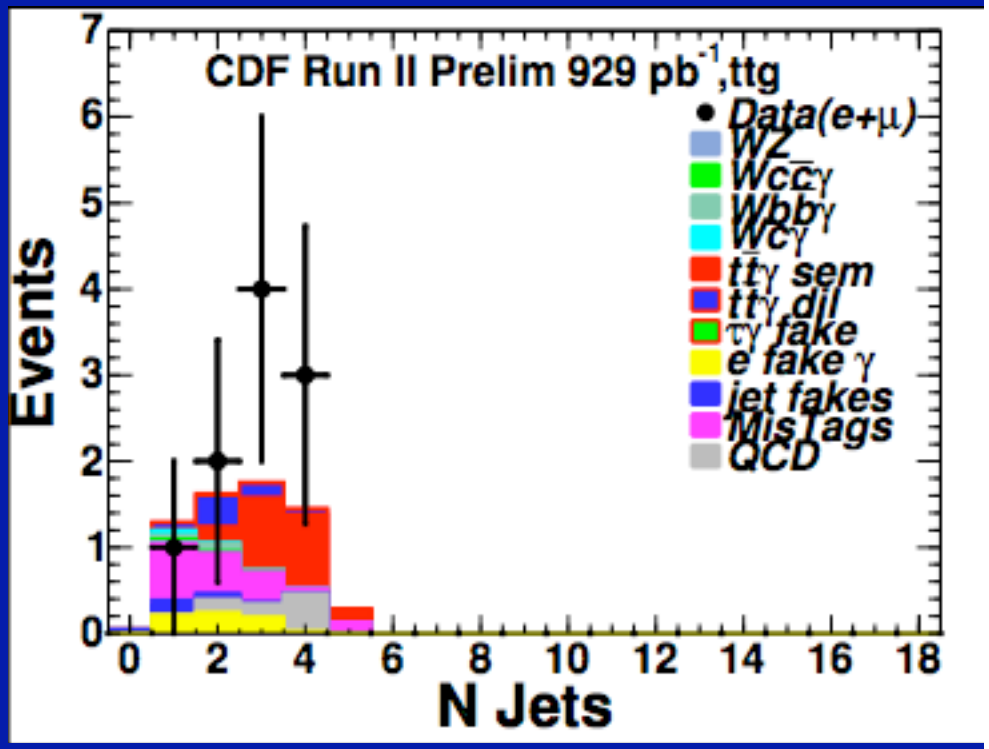
90.5 ± 6.0 (stat.) +21.7 -15.4 (syst) pb

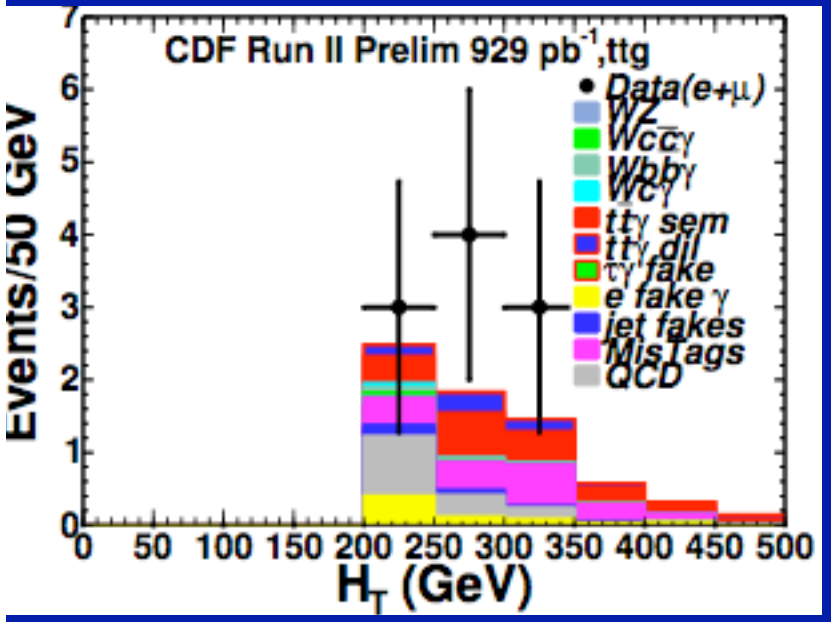
Pythia gen. Level: 69.3 pb

- Luminosity: 6%
- Trigger efficiency extrapolation (from statistics):10%
- Jet energy scale: 4% (from JES group methods)
- B purity templates: +20% -10%

Photon + b-jets + l + MET

Signature-based search for new physics, with ttγ as an obvious SM background for Njets>2.





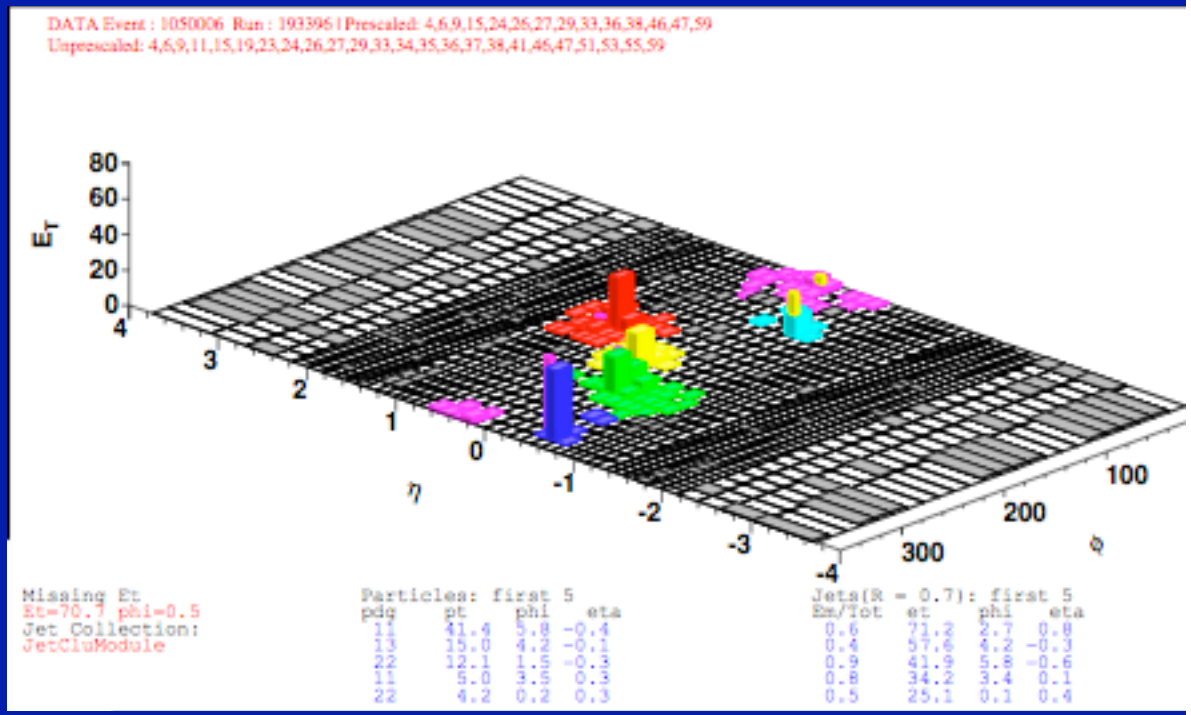
Results for l γ b MET H_T

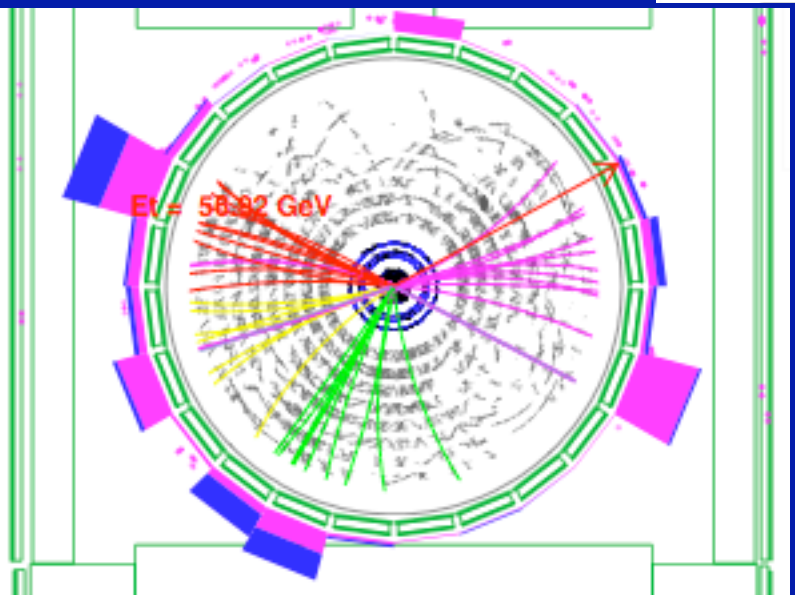
e	μ	e+μ
4.9±0.8	2.3±0.6	7.2±1.0
6	4	10

ttγ search: some candidates

Difficult analysis

Control sample for ttH (also at the LHC)





Results for l γ b MET H_T Njets>2

e	μ	e+μ
2.3±0.6	1.3±0.5	3.6±0.8
4	3	7

A lot of work is under way

- Slight discrepancy with theory confirmed in the high-statistics γ+jet analysis in D0
- While it probably does not require BSM physics, it will teach us something on interplay between fragmentation and leading-order
- Not enough precision to see discrepancies in the channels with HF final states and/or MET, but road is paved for these complex analyses
- A lot to learn even if data do not force you to change paradigm